LOCO update

C.Y. Tan
K. Seiya
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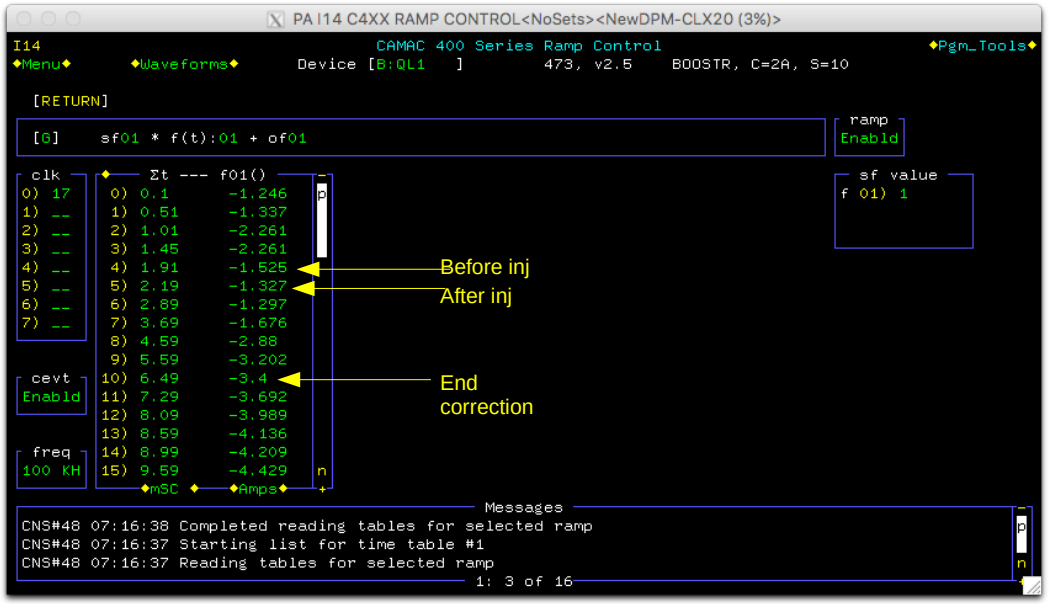
What's new software wise?

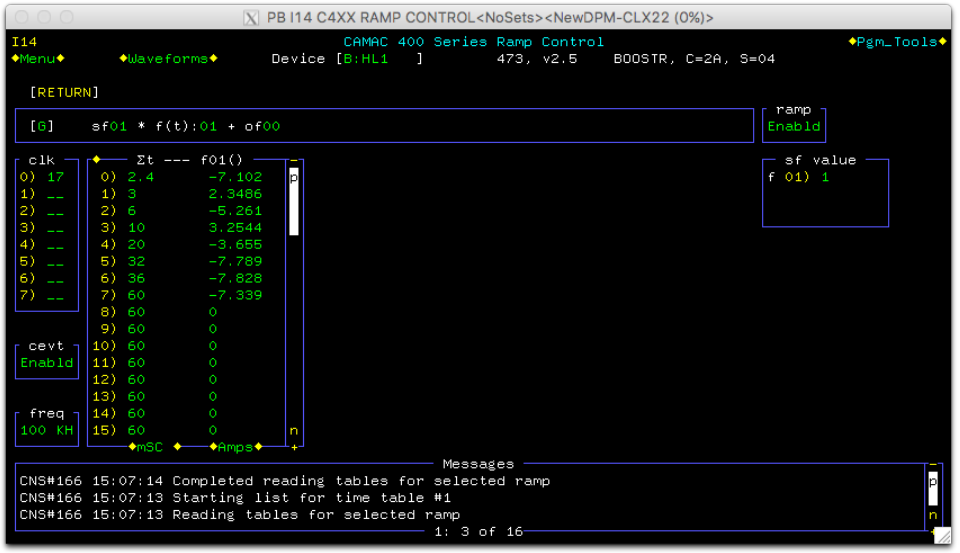
- New MADX lattice
  - Uses new MADX model that fixes quad and sextupole strengths so that they reproduce both tunes and chromaticities
    - Now has separate qsdqsf file found empirically from fitting measured data.
- LOCO program
  - General improvement of program
  - Make sure that the 465 slots are mapped correctly in the program
    - Changes to 465 dipole corrector slots not handled correctly has been fixed.
  - A lot of error checking to make sure that we are not using bogus results.

What's new in experiment?

- We decided to be less ambitious in performing LOCO corrections.
  - Only a small subset of slots are corrected so that any problems can be easily seen and hopefully solved.
    - See which slots are causing losses.
  - < 100% corrections can be applied to subset of slots.



Important to note about 465 cards



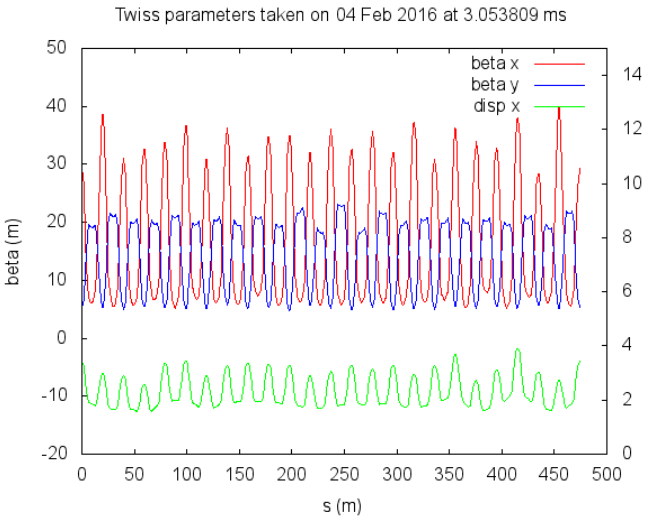
Dipoles first slot starts at 2.4 ms. The strength of the dipole is linearly interpolated from 0 ms to 2.4 ms.

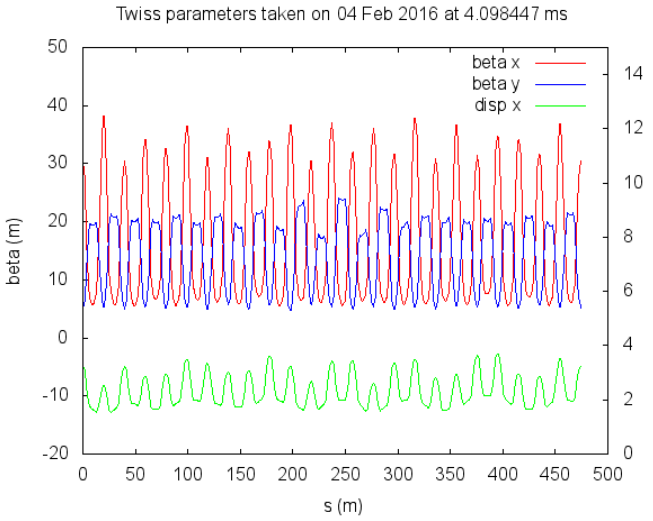
The closest slot after injection is at 2.19 ms for quads.

Beam is injected at 2 ms.

Beam is not bunched at 2 ms and so must wait for some bunching for the BPMs to work.

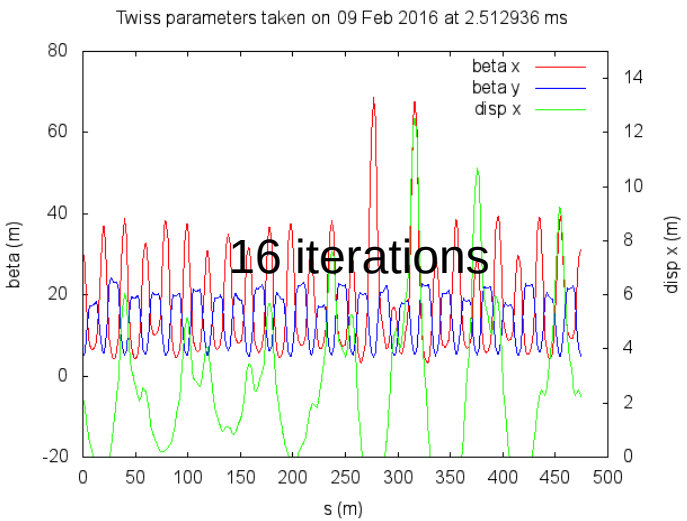
LOCO measurements before correction

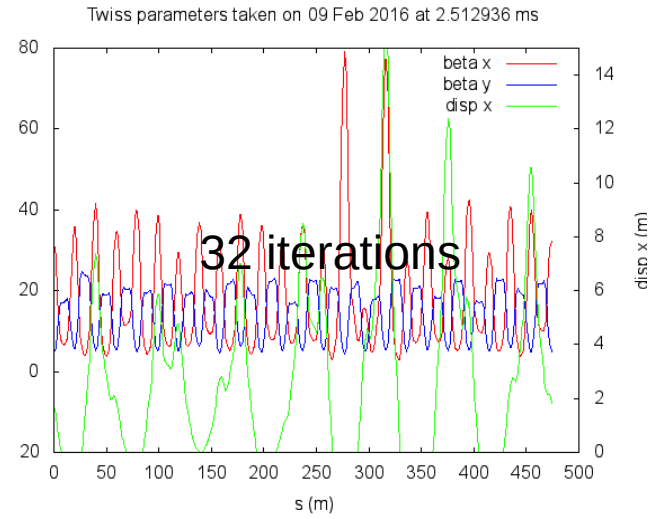


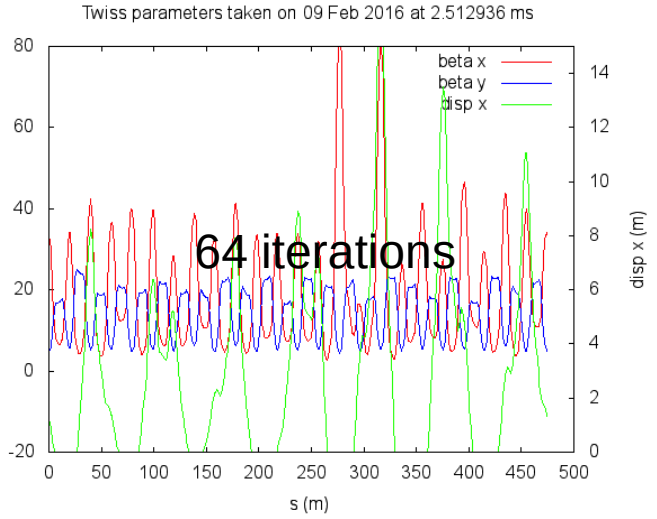


These are the first 6 slots of data collected, there's 2 more slots but these should be good representatives of what's going on.

Note that LOCO solution does NOT converge for 2.5 ms



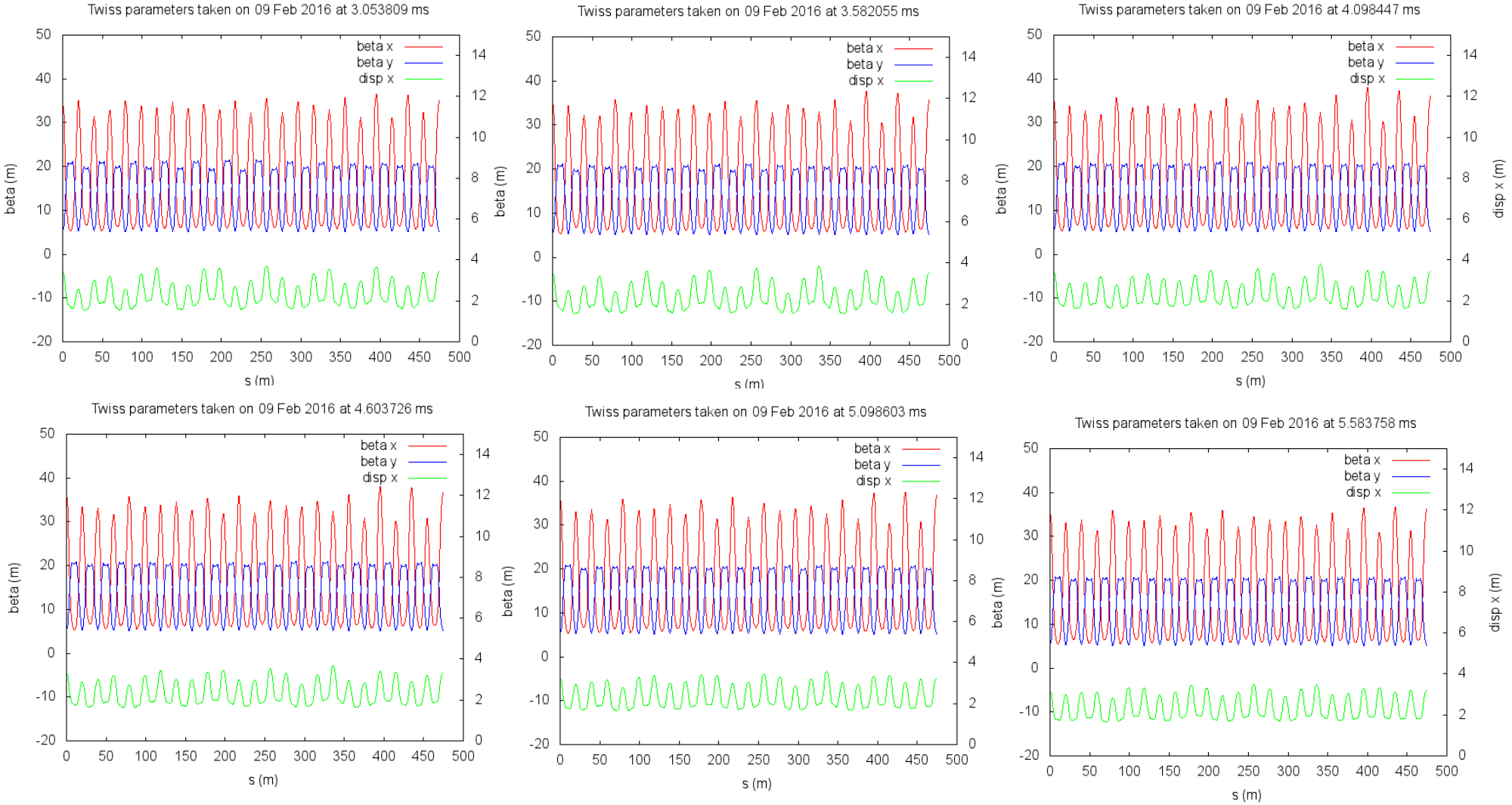




For some reason, 2.5 ms and earlier slots do not converge!
I suspect it is BPM's not reading orbits well at this time or there's a problem with “initial” values used by LOCO to fit the data.

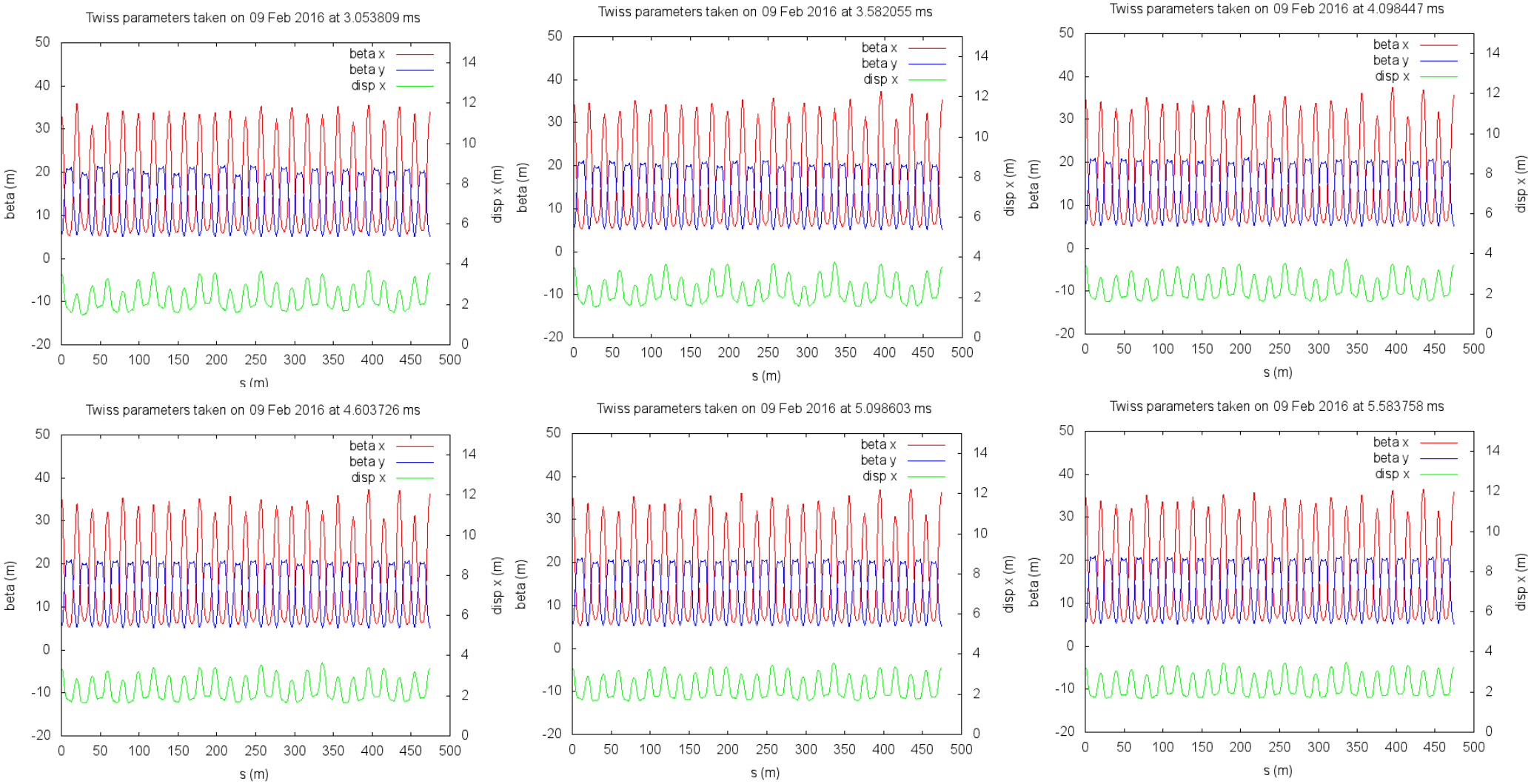
So, I will forego corrections before 2.5 ms.

After corrections applied from 2.9 ms to 6.7 ms (3 SVD iterations)



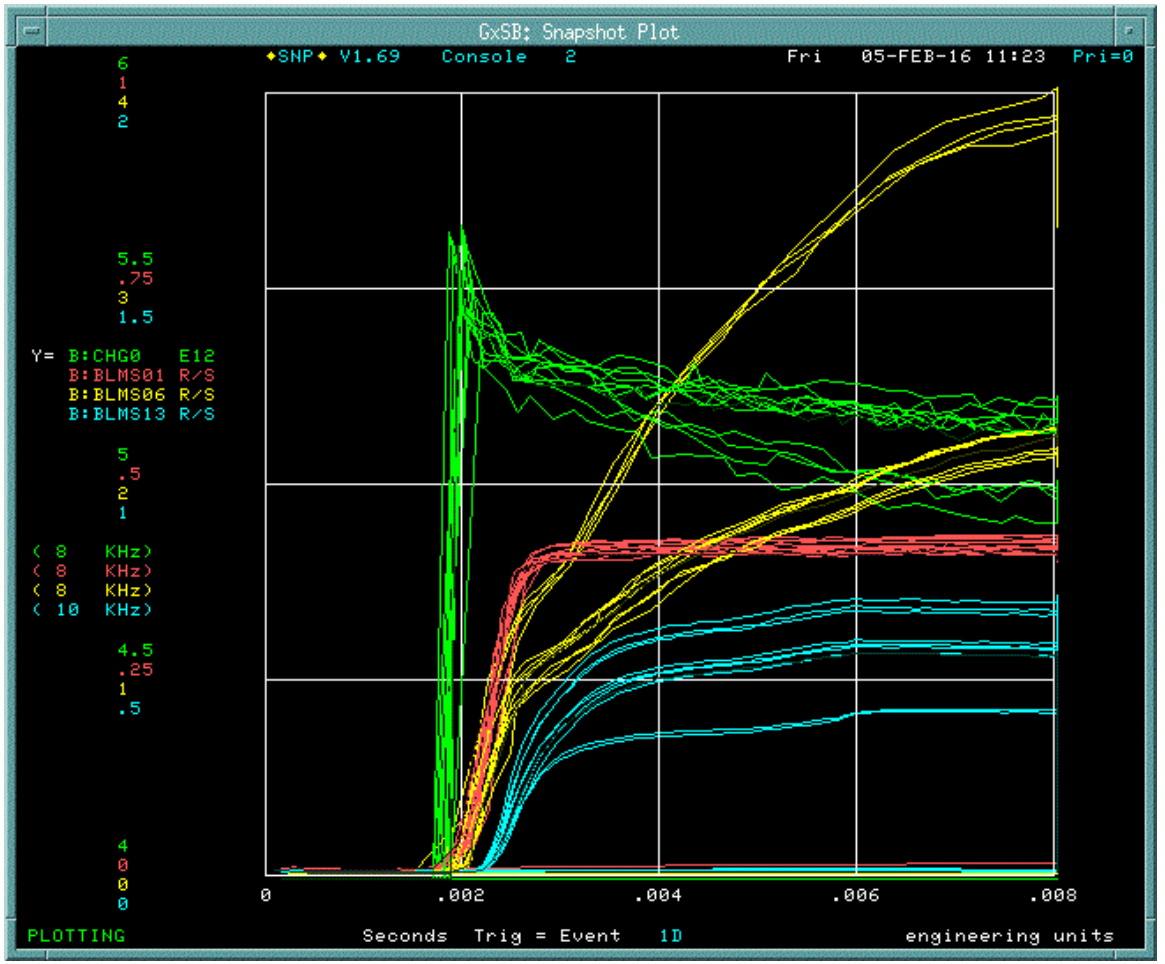
As found lattice doesn't look too bad with 3 SVD iterations. Let's do more iterations to check convergence.

After corrections applied from 2.9 ms to 6.7 ms (8 SVD iterations)



Solution definitely converges. This is what the lattice is in Booster after applying corrections measured on 04 Feb 2016 (if you believe LOCO)

Beam efficiency takes a hit at 100% correction from 2.9 ms to 6.5 ms



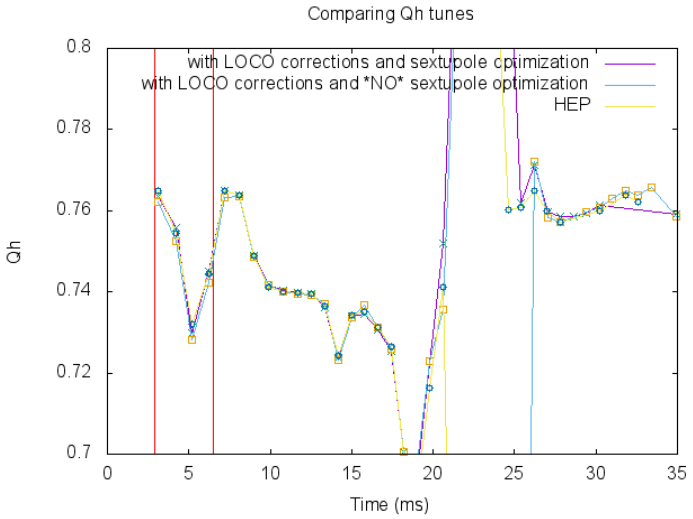
Efficiency is reduced by > 2% with 100% corrected lattice from 2.9 ms to 6.5 ms

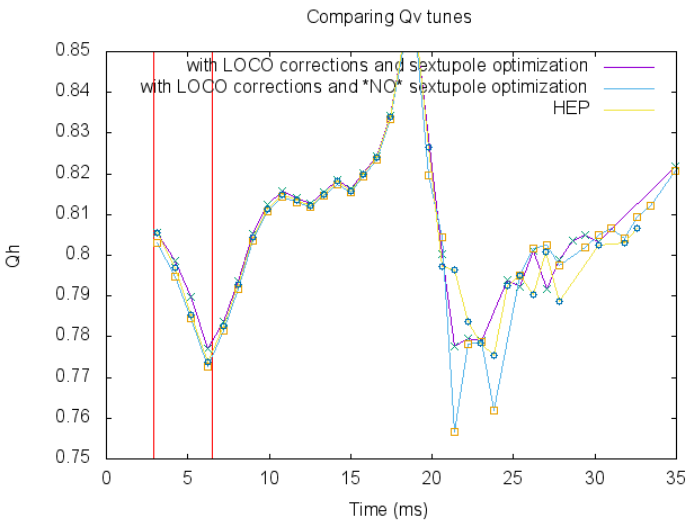
So where's the problem?

Trying to get back the 2%

Small orbit distortion in the horizontal plane. Fixed with HL6.

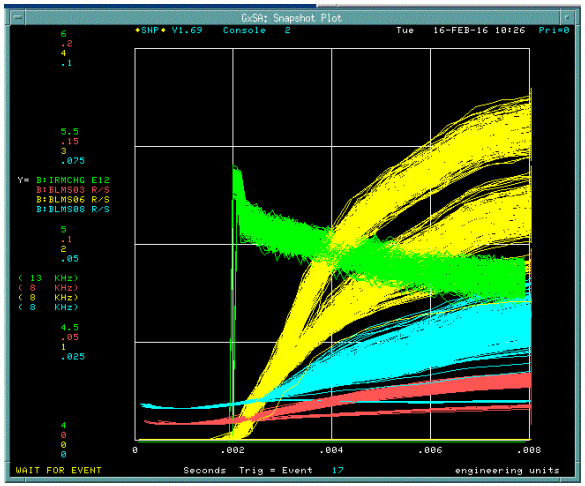
Greatest gain was with sextupole SXS change in 3.7 ms slot.

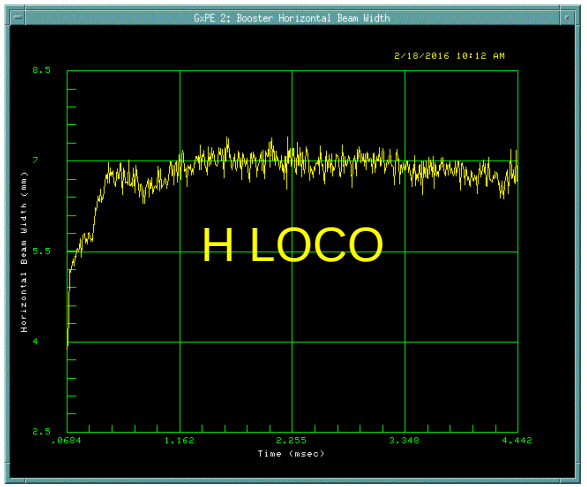


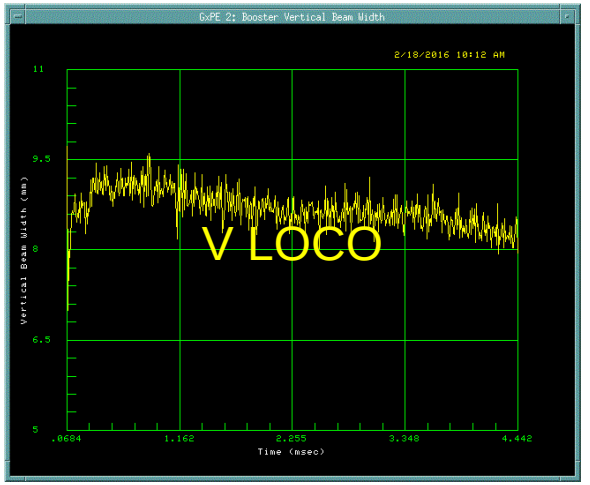


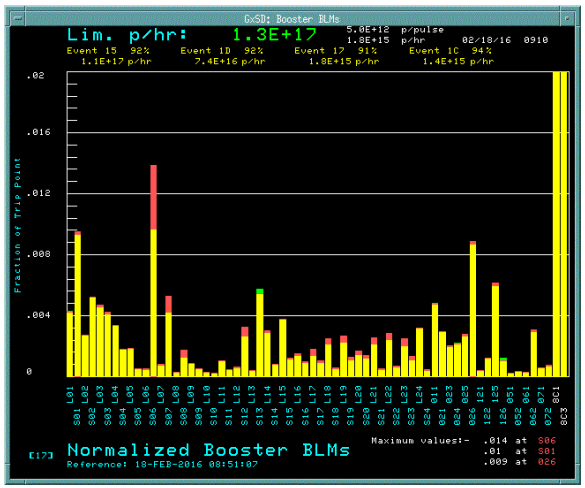
Very small tune shift (0.004) in the vertical after LOCO correction + sextupole correction.

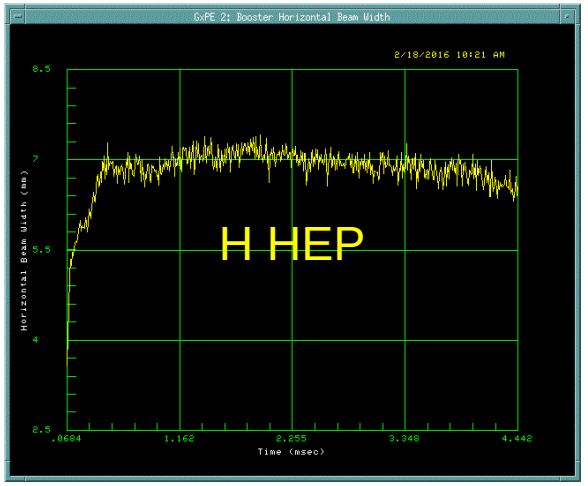
Very small gain after tuning with 100% correction

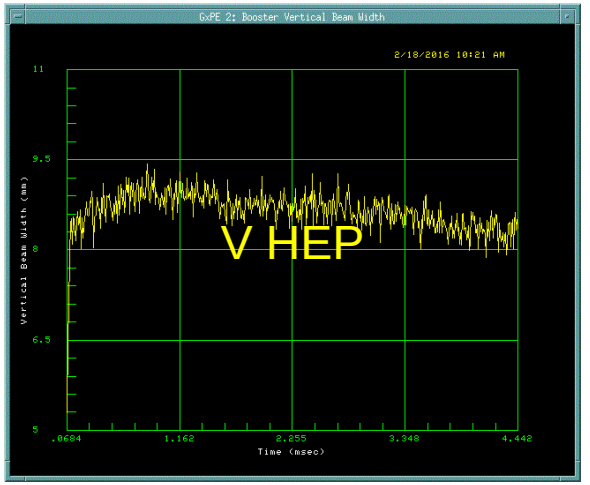






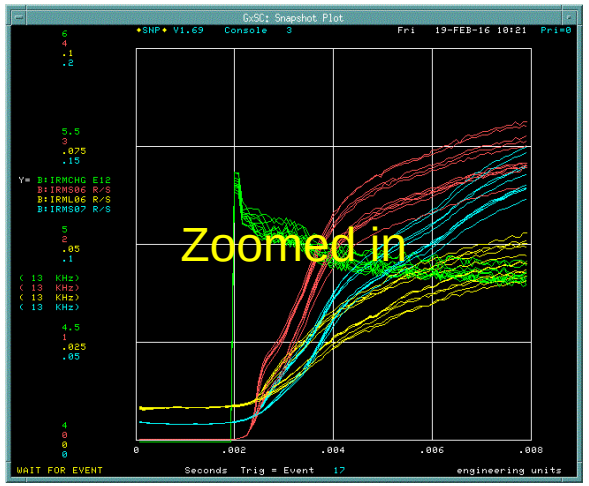


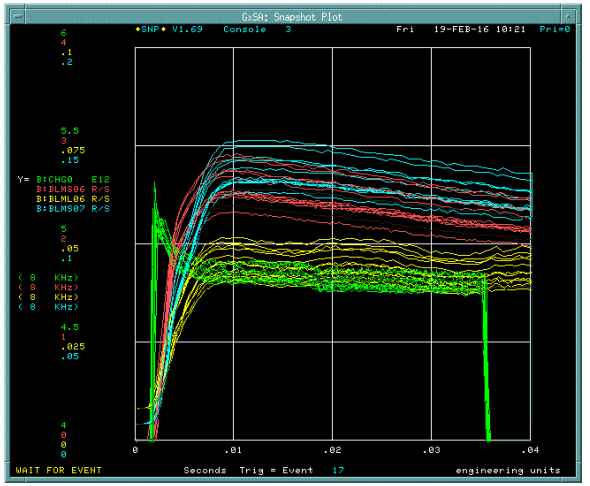


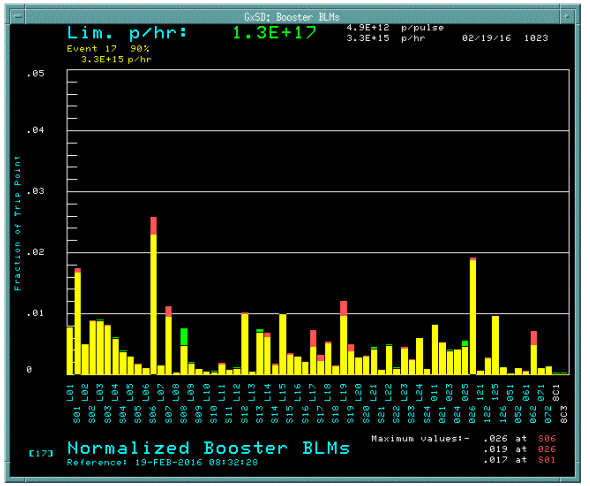


From the change in beta functions, expect beam size to be 4% larger (~1 tick box) horizontally between 3 ms to 3.7 ms (only slots changed). Vert should be the same. This is what we see if you stare long enough :) .
With tuning, we are still between 1 to 2% lower in efficiency than HEP.

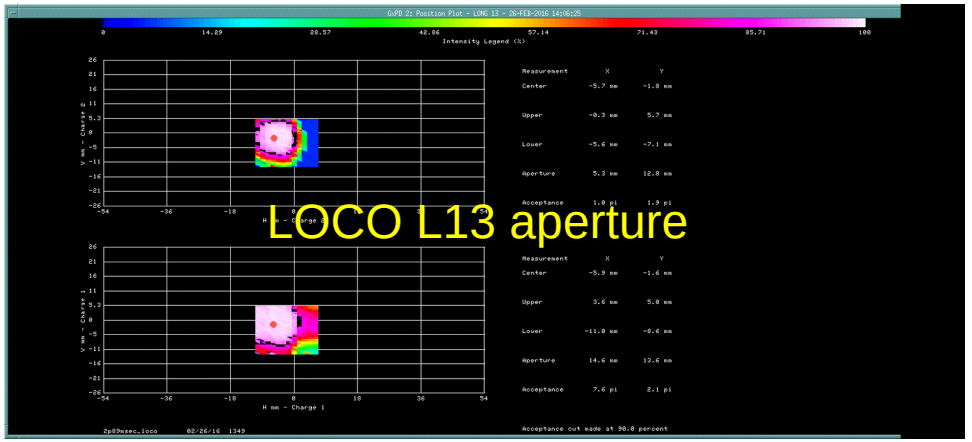
Are we losing beam at collimators and at L13?

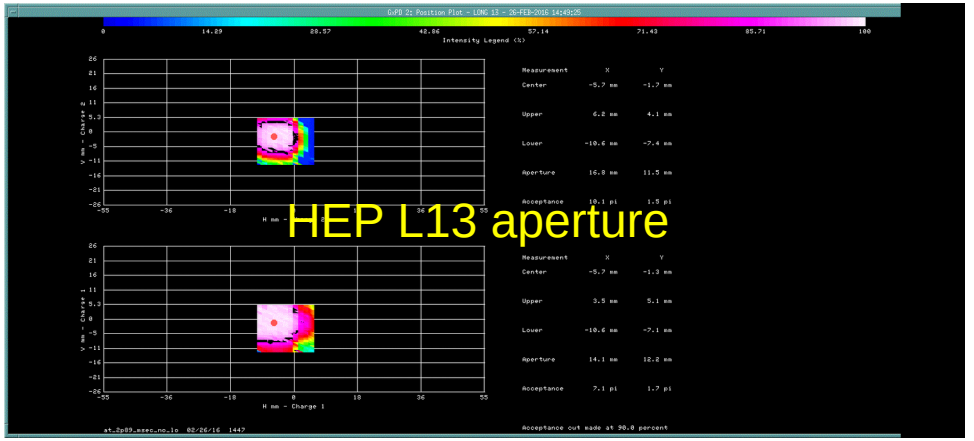






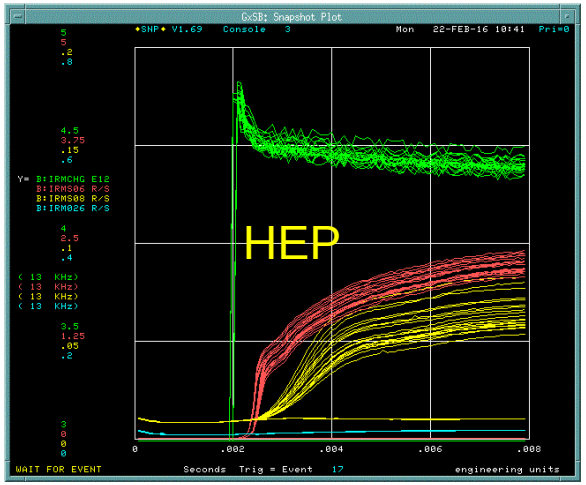
Greatest effect came from horz collimator 6B.
But efficiency still remained at ~90%, compared to HEP at 91 to 92%.





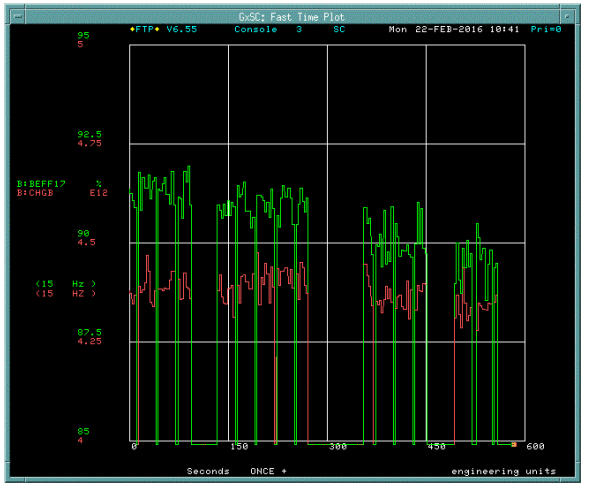
Essentially no change in aperture

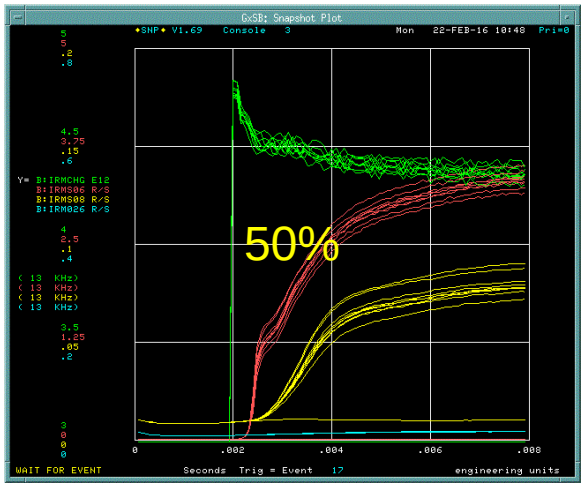
Reduce correction size

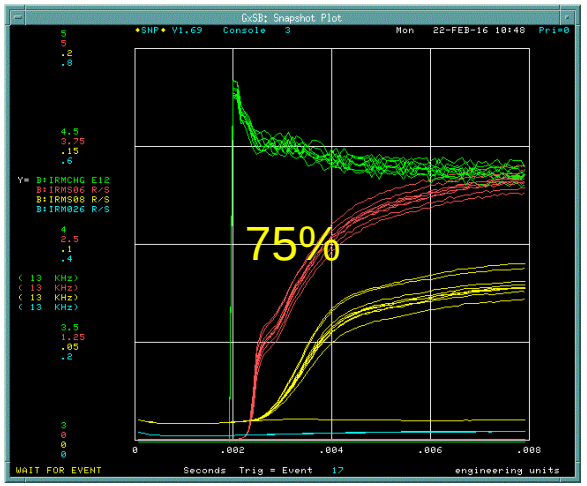


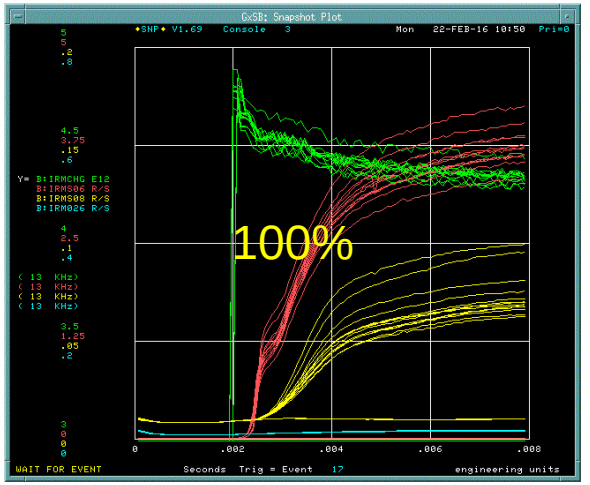
Efficiency gets lower as more correction is applied.

Let's try 75% correction and see what happens.

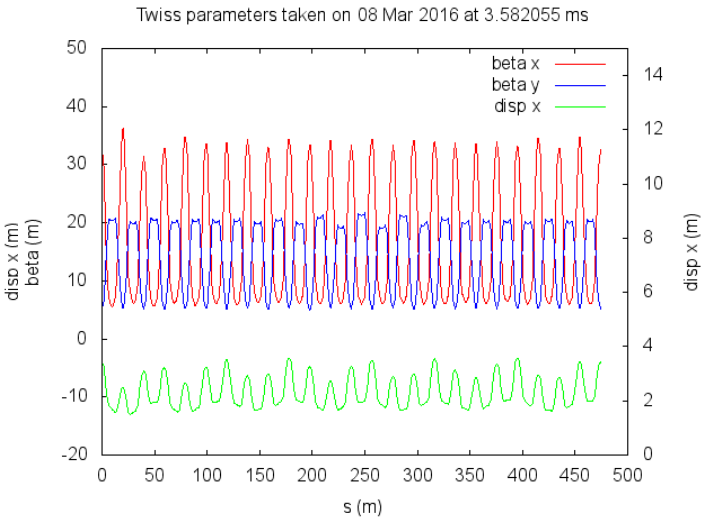


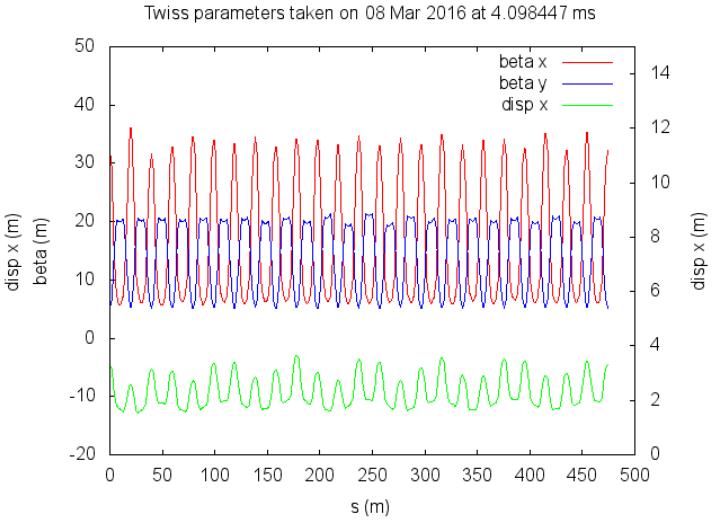


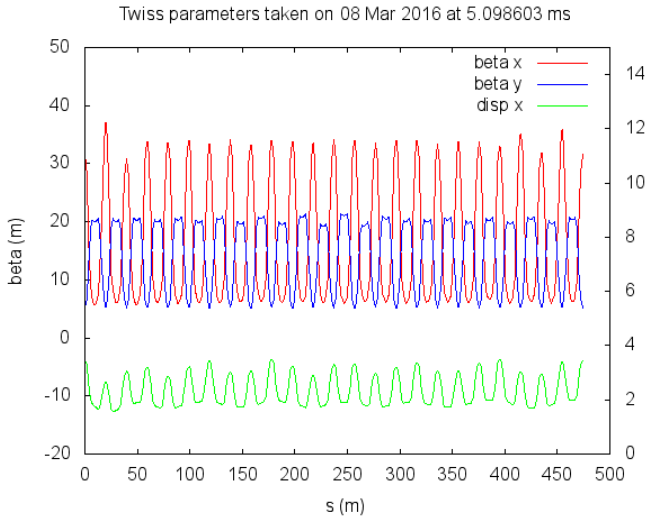


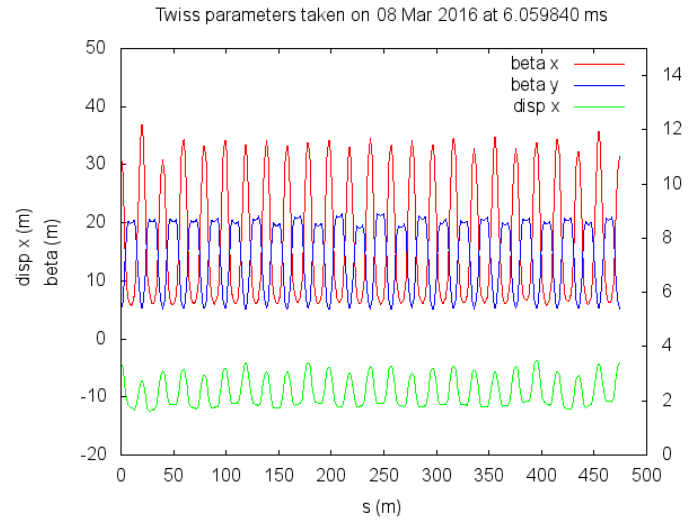


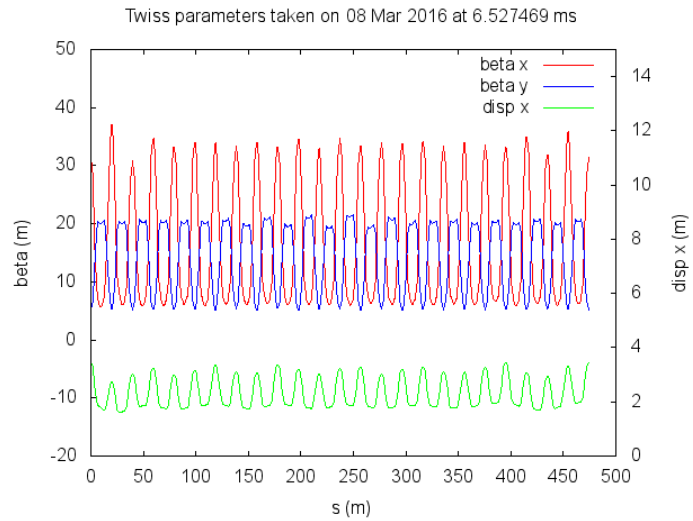
Measured 75% corrected lattice from 2.9ms to 6.5 ms (6 SVD iterations)





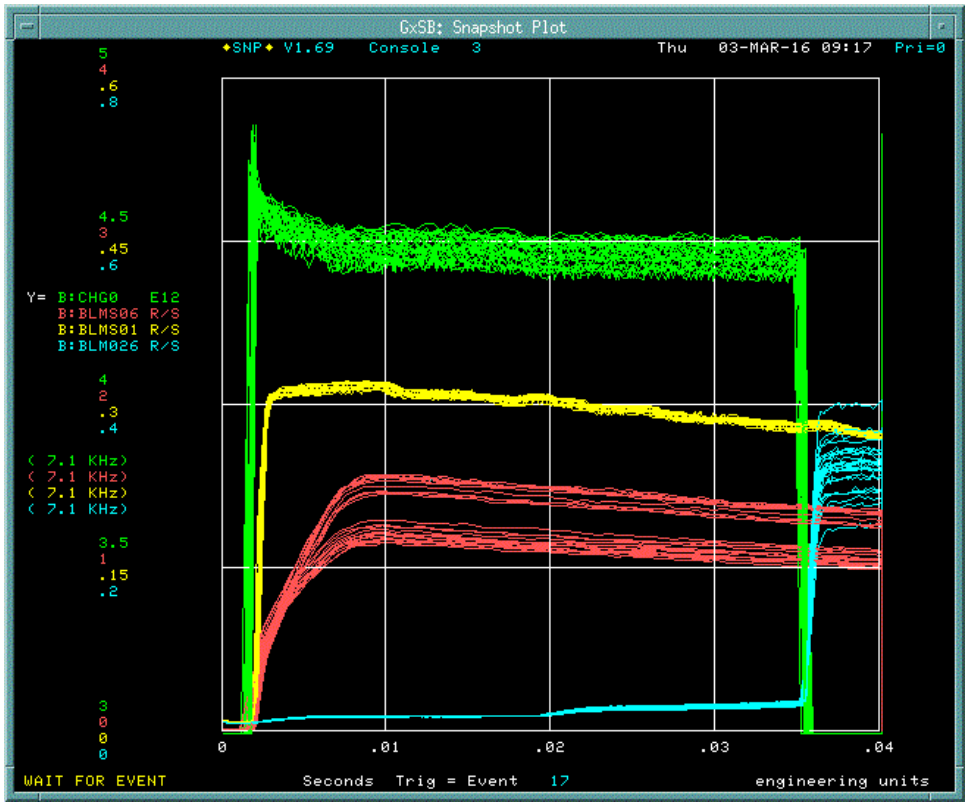


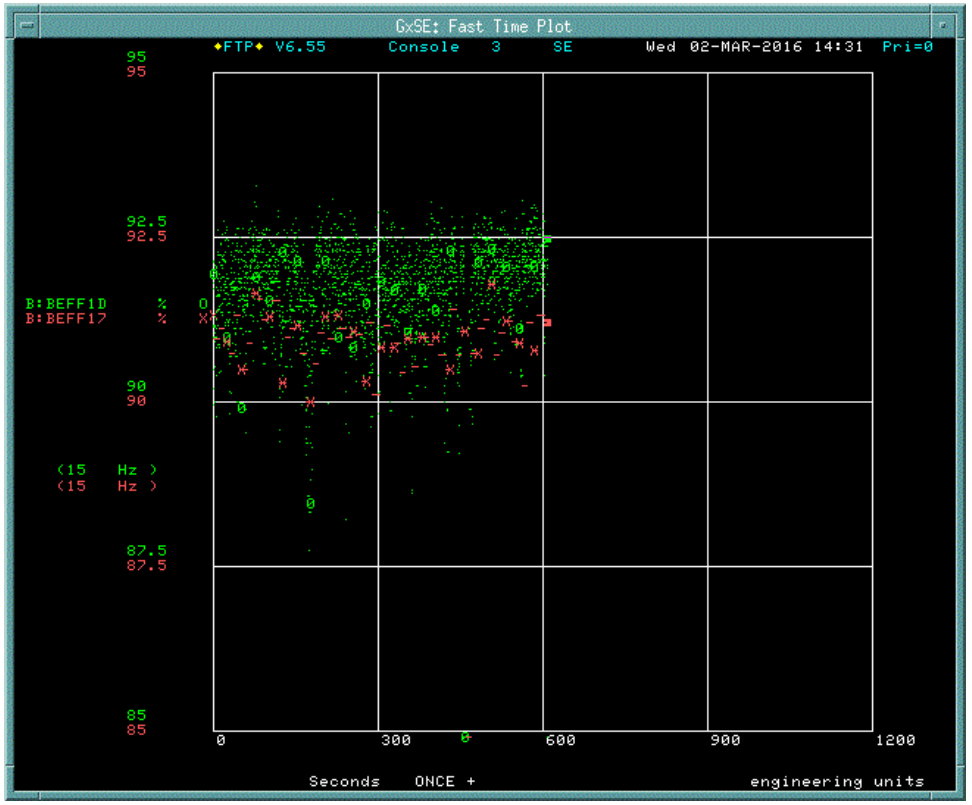




Surprisingly, 75% correction looks very good!

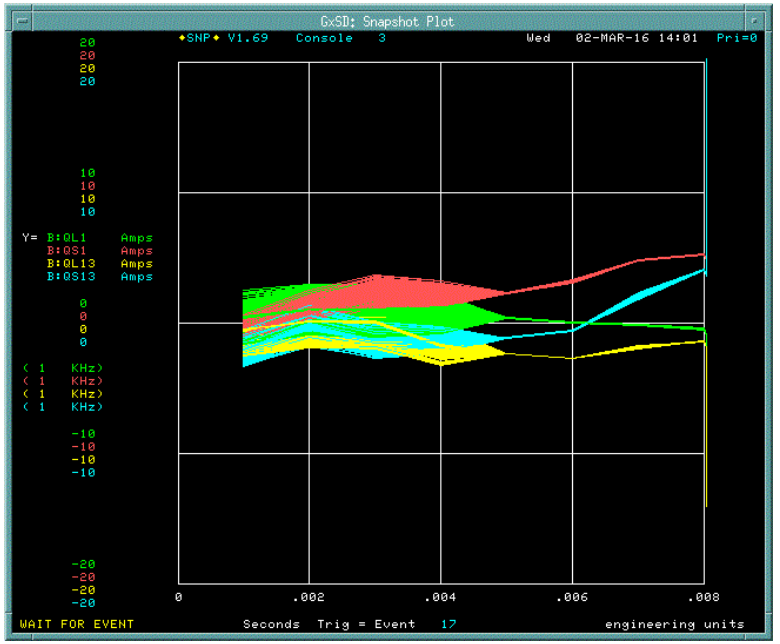
75% correction from 2.9 ms to 6.5 ms.





This gives consistently gives 0.5 to 1% efficiency difference rather than the 1 to 2% efficiency difference with 100% correction.

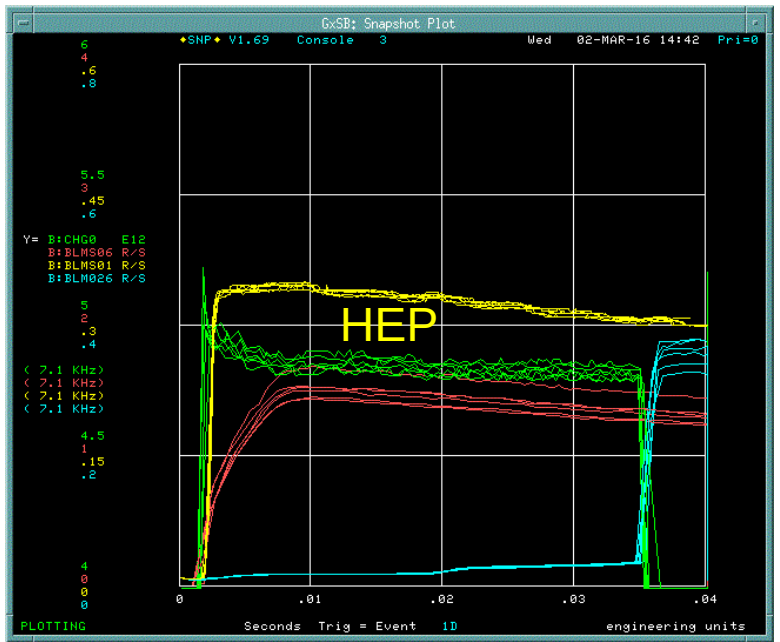
Tune scan



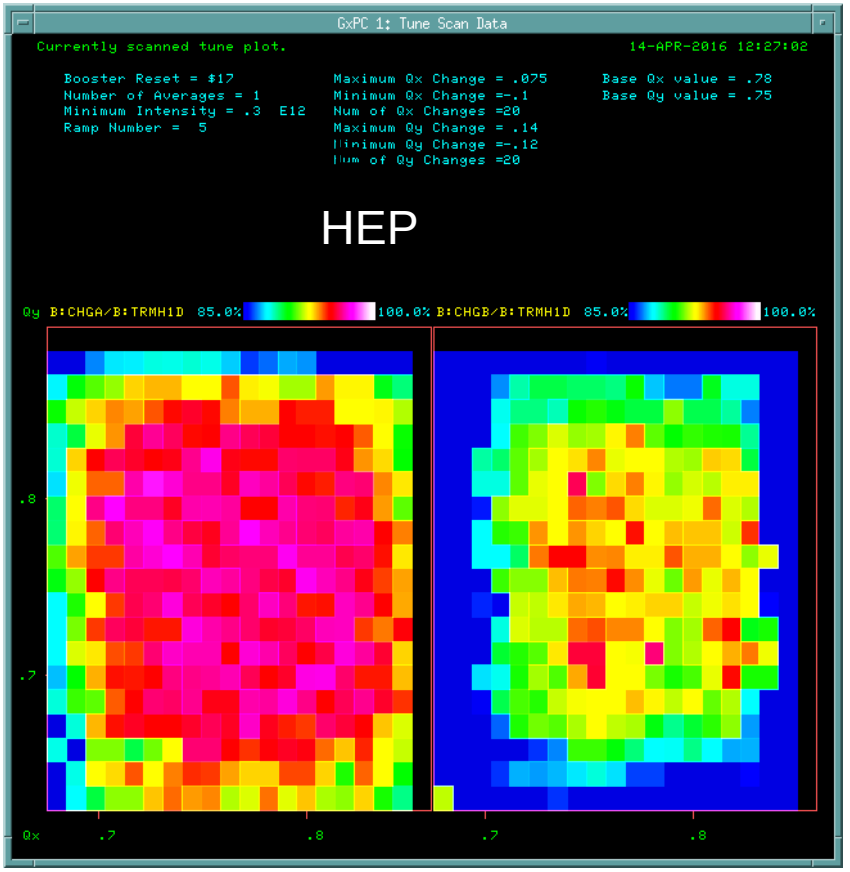
We did a tune scan to see whether we can recover the 1%.

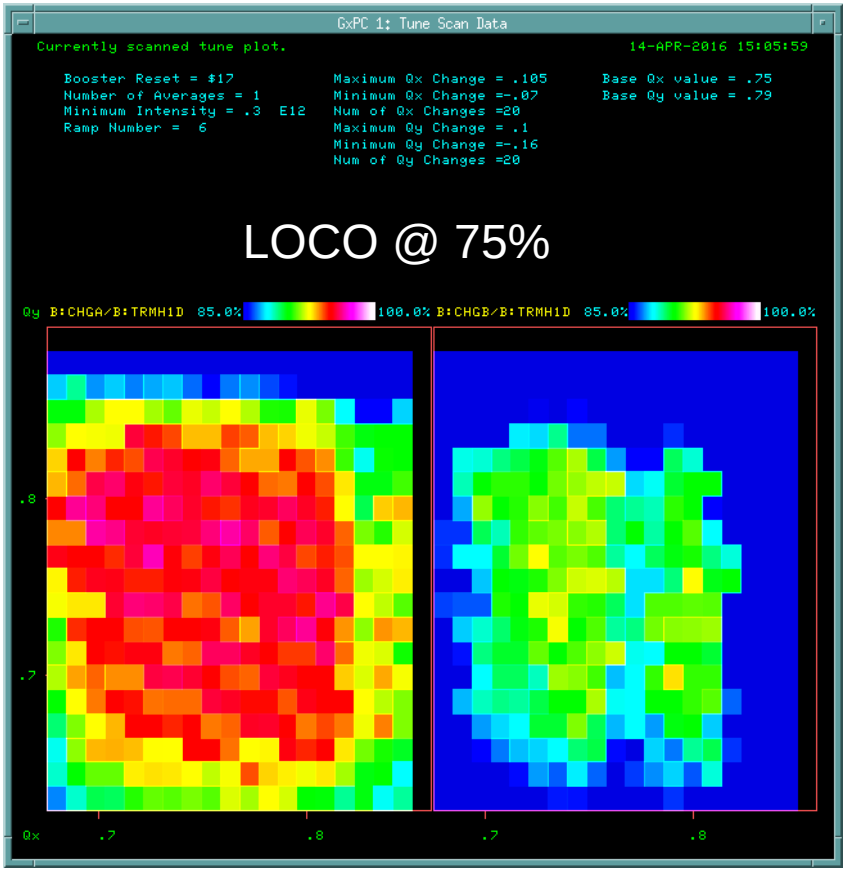
Tune scanned by +/- 0.05.

NO effect.



Tune space (3 ms)





The tune space became **smaller** with the LOCO lattice!

The experiment was done with HEP intensities (~4.5e12)

This can explain why we are always 0.5 to 1% smaller in efficiency. Is this due to larger tune spread or wider tune resonances?

Incoherent tune shift

$$\Delta\nu = \frac{\pi N r_0 R}{2\epsilon_N (v/c)\gamma^2}$$

Emittance smaller? Tune shift larger! Bad???? I doubt this is the case: NEED SIMS!

Conclusion

- LOCO results are MODEL dependent.
  - We did a lot of work to check that the model predicts tunes and chroms correctly.
  - A simulation needs to be done to recreate the tune scan results.
- Not clear what to do next. Recovering 1% is HARD!
  - Tunes don't move
  - Orbits have small distortion horizontally but correction does not help too much
  - Beam size changes due to changes in beta functions
    - Aperture scans and collimator moves don't fix loss
    - IPM measurements do show beam size larger. This is expected for the beta function change at that location.
  - Sextupole tuning has very small effect.
- What's the point?
  - Do we really gain from a “perfectly” corrected lattice?
    - Tune scan does not show any increase in tune space, in fact a decrease.
  - I don't want anecdotal statements that “ideal” lattice is better
    - Are there any simulations to tell us what the theoretical gain is, loss points are etc.
    - How much do we **really** gain from a corrected lattice in Booster?
- A lot of effort have been expended on this.
  - Opinion: No point doing this until we have simulation back up to any claims of gain.